OBSERVATION: BRIEF RESEARCH REPORT

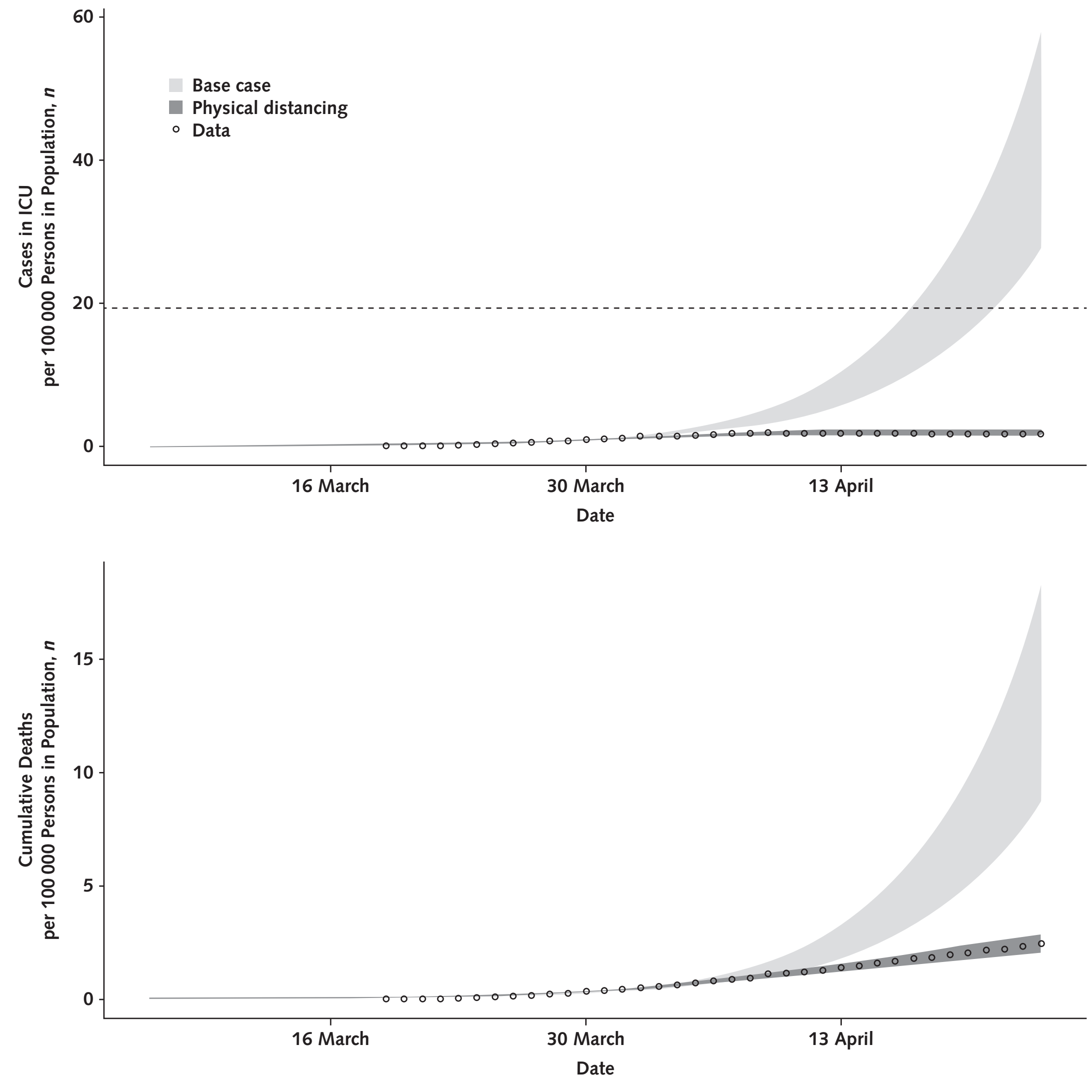
Risk for COVID-19 Resurgence Related to Duration and Effectiveness of Physical Distancing in Ontario, Canada

Background: Insights from epidemiologic models have helped to guide and improve understanding of mitigation policies for coronavirus disease 2019 (COVID-19) across the globe. As the pandemic progresses, models can be used to quantify what may unfold when such measures are relaxed.

Objective: To explore the effect of physical distancing measures on COVID-19 transmission in the population of Ontario, Canada.

Methods and Findings: We previously described a transmission model of COVID-19, stratified by age and health status, in the Canadian province of Ontario (1). It evaluated nonpharmaceutical interventions to control the COVID-19

Figure 1. Model-projected COVID-19 outcomes with and without physical distancing measures.



Prevalent cases in ICU (*top*) and cumulative deaths (*bottom*) are shown in the presence of physical distancing, which is assumed to reduce contacts to 30% of normal. Circles represent COVID-19 case data from Ontario, Canada, for 19 March to 3 May 2020. Deaths exclude those occurring outside the hospital (e.g., in long-term care facilities). Volatility in transmission was included to represent "superspreaders"–i.e., variation in the basic reproduction number (R_0) (some infected case patients transmit to many others, whereas other case patients transmit to far fewer)–so each model run draws a different value for R_0 leading to different trajectories. Bands represent the 95% credible intervals derived from 100 model simulations per scenario. The horizontal dashed lined in the top panel represents total ventilated ICU beds (19.3) per 100 000 persons in Ontario as a measure of maximum ICU capacity. After fitting, parameter values were as follows: mean R_0, 3.0; initial number of infected persons, 665; infectious period for mild infection, 4.3 d; infectious period for severe infection requiring hospitalization, 3.6 d; average length of stay in ICU, 13.1 d; and probability of death among case patients in ICU, 0.27. Fitted values were consistent with literature-based estimates as described in reference 1. COVID-19 = coronavirus disease 2019; ICU = intensive care unit.

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pandemic and preserve intensive care unit (ICU) capacity. The model found that physical distancing effectively mitigated spread but needed to be applied for long durations in either a sustained manner or with periodic dialing up and down of restrictions to prevent resurgence of infections and keep the number of cases requiring ICU care below ICU capacity.

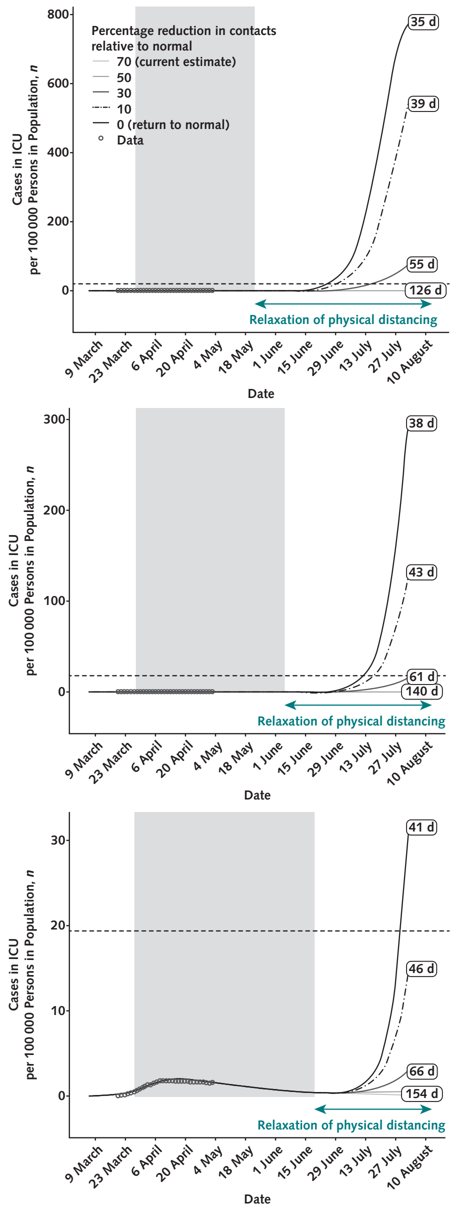
To update the model, we calibrated it to observed Ontario data using maximum likelihood estimation, incorporated recent data on durations of latent and presymptomatic periods (2), and revised values for the proportion of mild infections that were detected and isolated (10%) and the proportion of exposed cases that were quarantined (10%) based on data from local public health partners and other modeling groups (1, 3). We assumed a 70% reduction in contacts with the implementation of physical distancing measures (4) approximately 3 weeks after the model start date of 6 March 2020. Fitting involved varying the basic reproductive number (R_0), initial number of infected persons, infectious period, and average length of ICU stay, with all other parameters unchanged (1).

After being fitted to confirmed case patients occupying ICU beds and COVID-19–attributable deaths among hospitalized case patients in Ontario for 19 March to 3 May 2020 (Figure 1), the model projected up to 37.4 cases (95% credible interval [CrI], 27.7 to 59.4 cases) in ICUs per 100 000 persons in the population without intervention, compared with 2.0 cases (95% CrI, 1.6 to 2.3 cases) per 100 000 with physical distancing. Similarly, deaths among hospitalized case patients without intervention (12.7 deaths [95% CrI, 9.9 to 18.7 deaths] per 100 000) were 5-fold higher than with physical distancing (2.5 deaths [95% CrI, 2.0 to 2.9 deaths] per 100 000).

Relaxation of physical distancing measures without compensatory increases in case detection, isolation, and contact tracing was projected to result in a resurgence of disease activity. Figure 2 illustrates the number of days until ICU capacity may be exceeded when contact rates are varied from 70% to 0% of normal after a period of 8 to 12 weeks with strong reductions in contacts (70%). A return to normal levels of contact would rapidly result in cases exceeding ICU capacity. Maintaining physical distancing for a longer period delayed this resurgence, but the level of contact after restrictive distancing was the major factor determining how quickly ICU capacity was expected to be overwhelmed.

Discussion: To date in Ontario, the number of cases in ICUs has remained below current (recently expanded) ICU capacity. The provincial response was initiated in mid-March with the declaration of a state of emergency on 17 March 2020. Without intervention, we projected that Ontario would have rapidly exceeded ICU capacity and observed substantially higher mortality. Our modeling also shows the challenges associated with relaxation of physical distancing measures without a concomitant increase in other public health measures. Specifically, when the number of contacts between persons returns to more than 50% of normal, we expect disease activity to resurge rapidly and ICUs to quickly reach capacity. Our model results suggest that in the absence of improved capacity for testing and contact tracing as a means of controlling COVID-19 spread, policymakers could consider staged relaxation of physical distancing and monitor changes in contacts (for example, using digital approaches) as an early warning signal.

Figure 2. Effect of relaxation of physical distancing measures on projected ICU requirements and days until ICU capacity would be exceeded.



Results are shown for 8-wk (*top*), 10-wk (*middle*), and 12-wk (*bottom*) periods of physical distancing before relaxation of distancing measures. Results are shown here for fixed stable values (a deterministic version of the model without variation in the transmission term/basic reproduction number [R_0]) to enable comparison across multiple scenarios. The gray shaded area represents the period during which restrictive physical distancing measures were in place, with contacts reduced by 70% of normal, consistent with reference 4. After these variable periods of restrictive distancing, contact rates were allowed to increase in the period indicated by the horizontal arrow. Baseline contact rates (without physical distancing) were derived from the work of Mossong and colleagues (PLoS Med. 2008;5:e74). Maximum ICU bed capacity in Ontario is indicated by the dashed horizontal line (19.3 ventilated beds per 100 000 persons in the population). The labels indicate time until ICU capacity is exceeded after relaxation of physical distancing measures. Note that for some scenarios, the time until ICU capacity is surpassed extended beyond the time scale shown in the graphs; we restricted the *x*-axis to aid comparison among the scenarios. If contacts remain at 70% of normal, ICU capacity is not projected to be exceeded, so no labels appear for this scenario. Different *y*-axis scales are shown across panels to aid interpretability. ICU = intensive care unit.

A limitation of our model is that it was fitted to mortality among hospitalized case patients; thus, the results presented here apply to community transmission. Ontario, like many other jurisdictions, is experiencing outbreaks in long-term care homes. To date, 65% of confirmed COVID-19 deaths in the province have occurred outside hospitals, and there is a divergence between trends in hospitalizations and mortality that represents different pathways of care for persons in long-term care homes (5). Understanding and describing the dynamics of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) transmission in long-term care homes and other institutional settings is important for protecting the most vulnerable members of our society and requires alternate modeling approaches and control measures.

We show deterministic outputs for the epidemic projections with different levels of relaxation of physical distancing. Given variability in R_0, local community transmission may be eliminated or time to resurgence delayed. However, as long as SARS-CoV-2 is circulating globally, population susceptibility remains, and while we have open borders, the risk for reintroduction and resurgence continues. Our results show the challenges that lie ahead as we move to the deescalation phase of the first wave of the pandemic.

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Reproducible Research Statement: *Study protocol:* Correspondence regarding methodological issues should be directed to Dr. Fisman (e-mail, david.fisman@utoronto.ca). *Statistical code:* Available at https://github.com/ashleighrt/Ontario-COVID19-model. *Data set:* Data used for fitting are not publicly available.

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